US007156620B2

(12) United States Patent
Papple

(10) Patent No.: US 7,156,620 B2
(45) Date of Patent: Jan. 2, 2007

(54) **INTERNALLY COOLED GAS TURBINE AIRFOIL AND METHOD**

(75) Inventor: **Michael Leslie Clyde Papple**, Ile des Soeurs (CA)

(73) Assignee: **Pratt & Whitney Canada Corp.**, Longueuil (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 87 days.

(21) Appl. No.: **11/016,833**

(22) Filed: **Dec. 21, 2004**

(65) **Prior Publication Data**

US 2006/0133936 A1 Jun. 22, 2006

(51) **Int. Cl.**
B63H 1/14 (2006.01)

(52) **U.S. Cl.** .... **416/96 R**; 415/115; 415/116

(58) **Field of Classification Search** .... 416/96 R, 416/96 A, 97 R, 97 A; 415/115, 116
See application file for complete search history.

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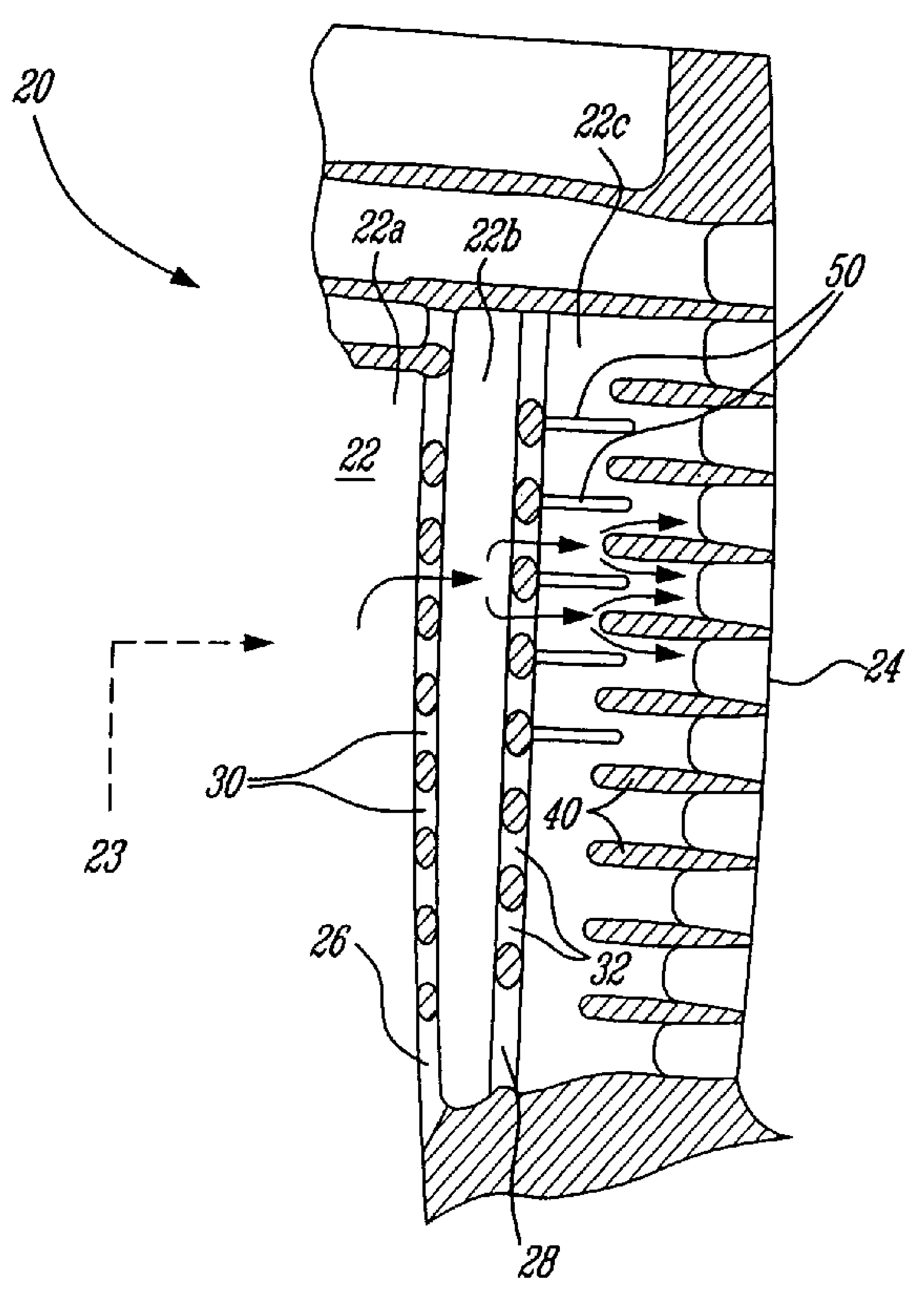
Primary Examiner—Hoang Nguyen
(74) *Attorney, Agent, or Firm*—Ogilvy Renault LLP

(57) **ABSTRACT**

An internally cooled airfoil for a gas turbine engine, wherein a plurality of elongated cooling fins are provided inside the concave sidewall.

18 Claims, 4 Drawing Sheets



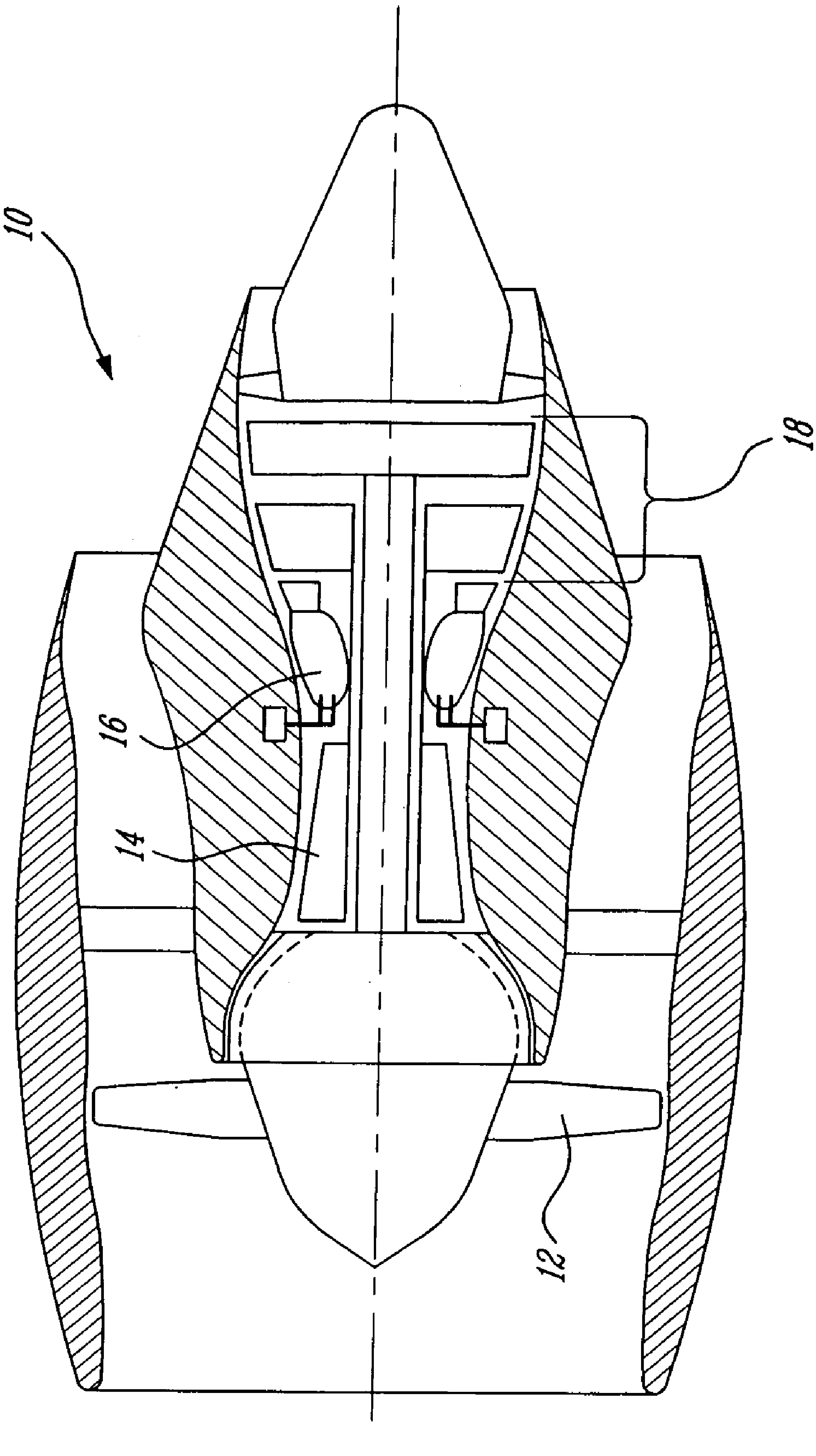


Fig. 1

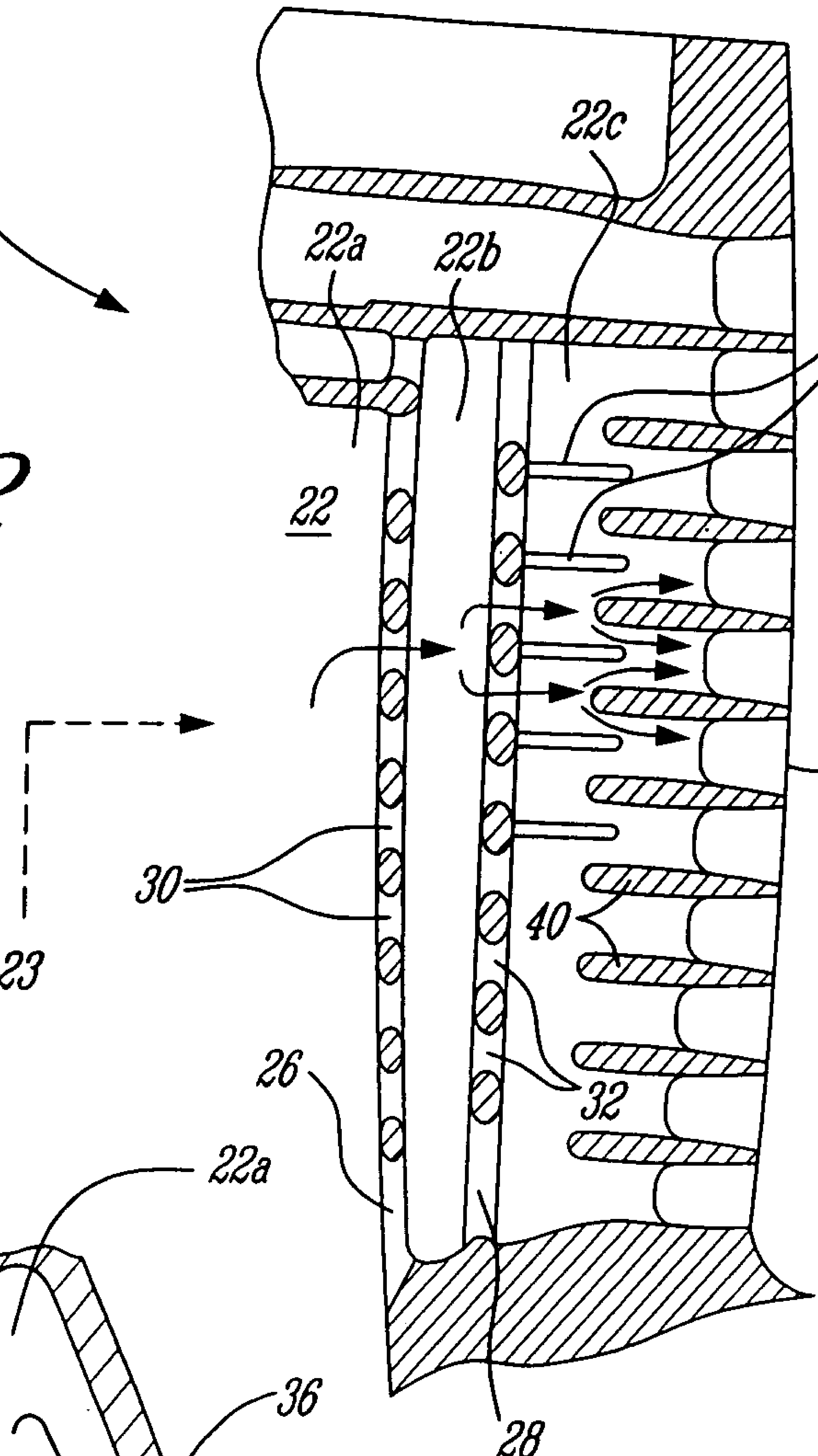
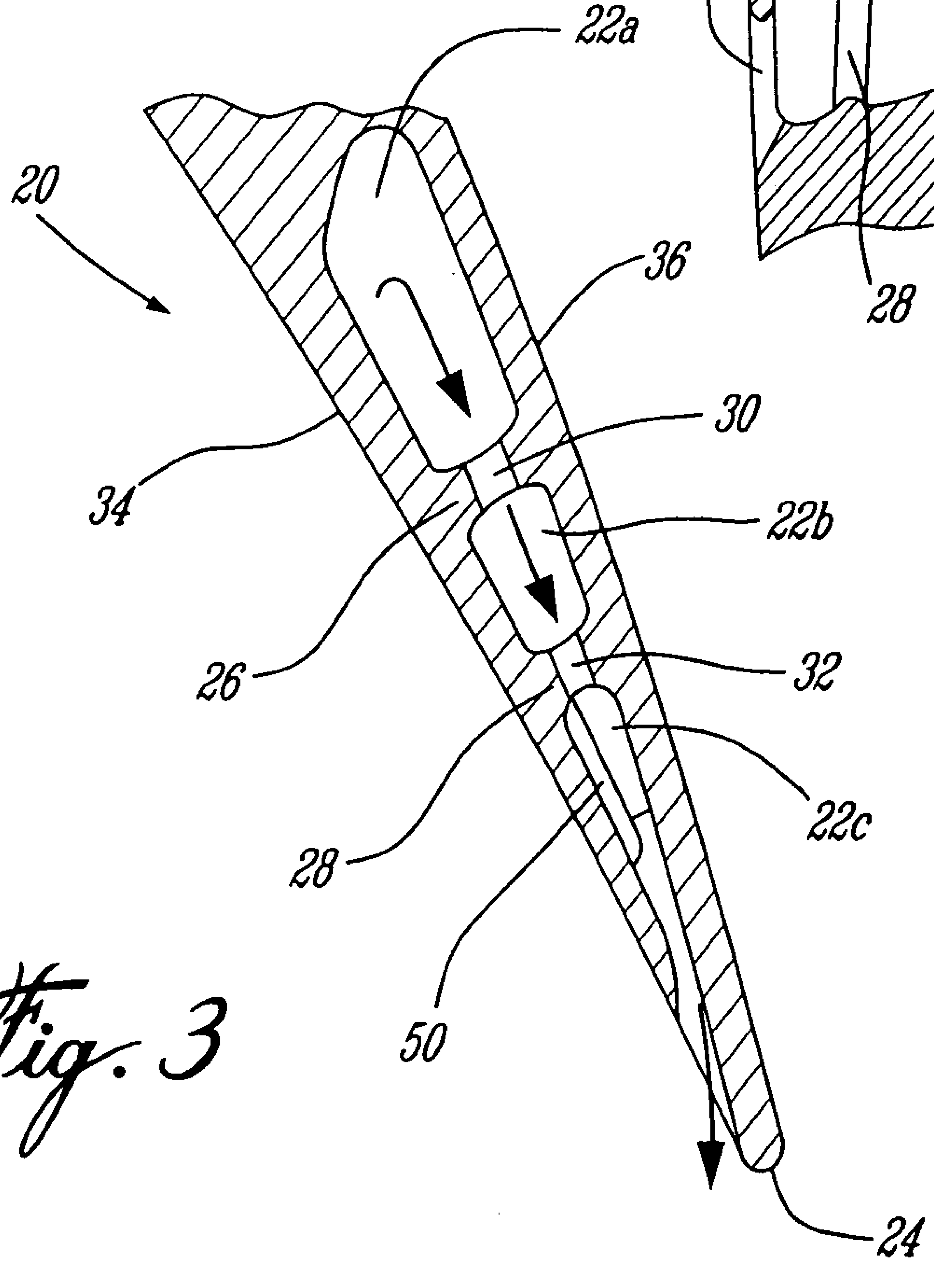

20
22c
22a
22b
50
22
24
30
40
23
26
32
28

Fig. 2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20
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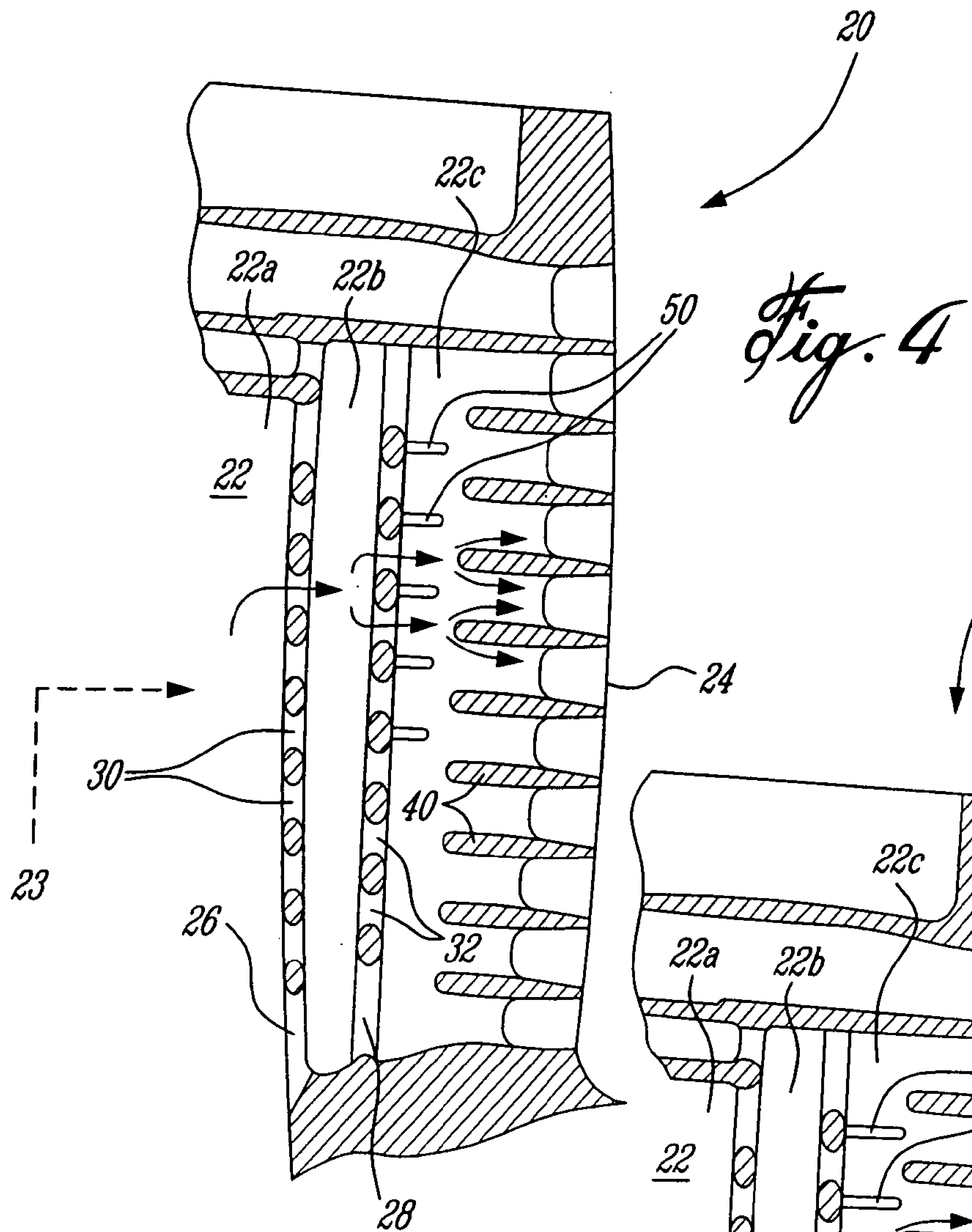
22c
50
24

Fig. 3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22c
22a
22b
50
22
24
23
30
40
32
26
28

Fig. 4

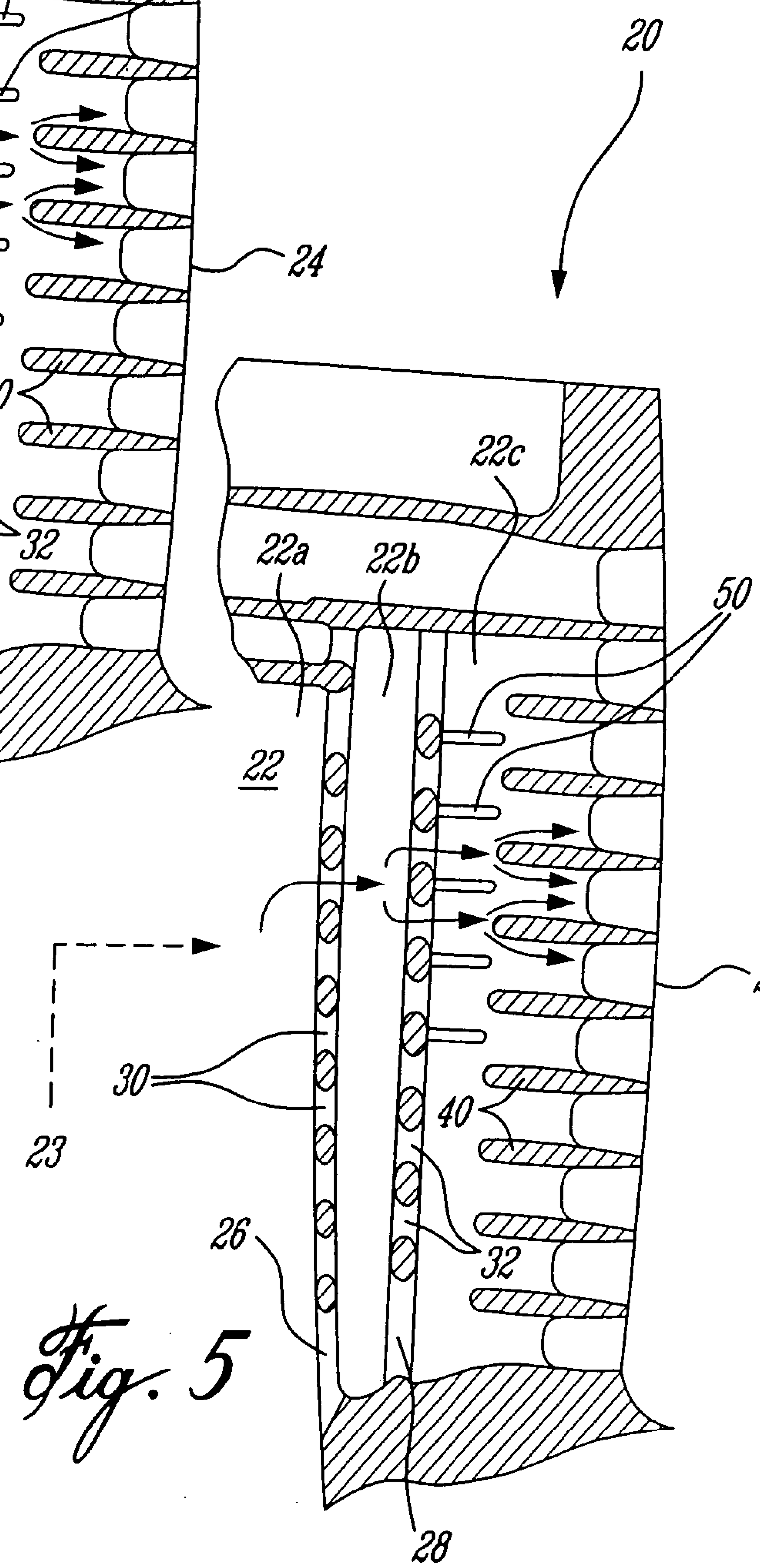
20
22c
22a
22b
50
22
24
23
30
40
32
26
28

Fig. 5

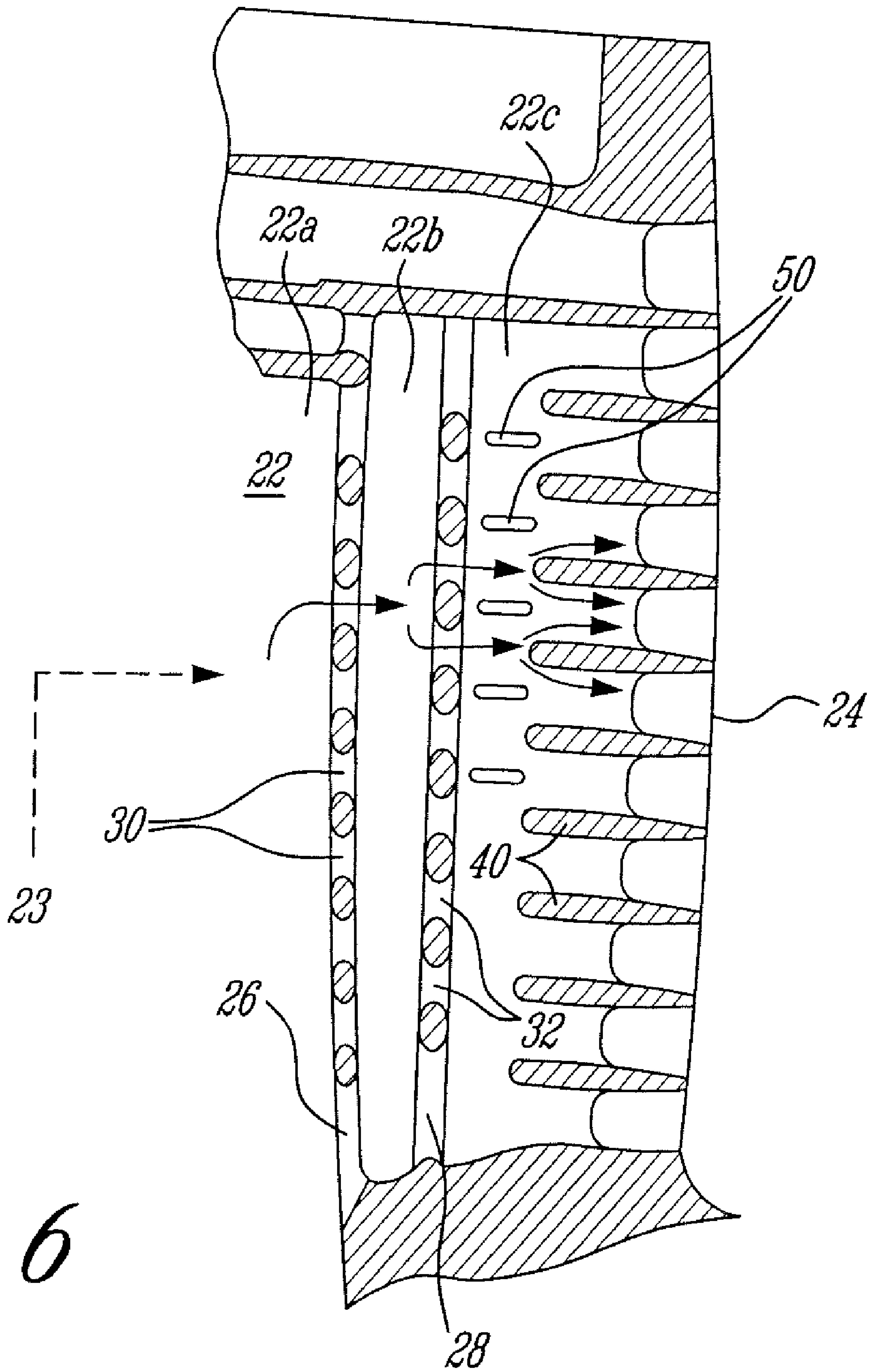

Fig. 6

INTERNALLY COOLED GAS TURBINE AIRFOIL AND METHOD

TECHNICAL FIELD

The field of the invention generally relates to internally cooled airfoils within gas turbine engines.

BACKGROUND OF THE ART

While many features have been provided in the past to maximize the heat transfer between cooling air and the airfoil, the design of gas turbine airfoils is nevertheless the subject of continuous improvements so as to further increase cooling efficiency without significantly increasing pressure losses inside the airfoil. An example of such area is the concave or pressure side of an airfoil, near the trailing edge. For instance, U.S. Pat. Nos. 6,174,134 and 6,607,356 disclose various structures intended to introduce turbulence in this region to enhance cooling efficiency, albeit at the price of an added pressure drop. Despite these past efforts, there is still a need to improve the cooling efficiency in some areas of airfoils.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides an internally cooled airfoil for a gas turbine engine, the airfoil having at least one internal cooling passageway generally positioned between opposite concave and convex sidewalls, and a trailing edge outlet, the airfoil comprising: a crossover located in the passageway and being adjacent to the trailing edge outlet, the crossover comprising a plurality of crossover holes; and a plurality of elongated cooling fins provided inside the concave sidewall between the crossover and the trailing edge outlet.

In a second aspect, the present invention provides an airfoil for use in a gas turbine engine, the airfoil comprising a convex side, a concave side and a trailing edge at a rearmost portion of the airfoil, the airfoil having at least one internal cooling passageway, the airfoil comprising a plurality of internal cooling fins located inside the passageway and extending from the concave side upstream the trailing edge.

In a further aspect, the present invention provides a method of enhancing the cooling an airfoil of a gas turbine engine, the airfoil comprising at least one internal cooling passageway generally positioned between a concave sidewall and a convex sidewall, and a trailing edge outlet, the method comprising: providing a crossover located in the passageway and adjacent to the trailing edge outlet, the crossover comprising a plurality of crossover holes; providing a plurality of elongated cooling fins inside the concave sidewall between the crossover and the trailing edge outlet; and circulating an airflow inside the passageway, the airflow running through the crossover holes and then over the fins before exiting at the trailing edge outlet.

Further details of these and other aspects of the present invention will be apparent from the detailed description and figures included below.

DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying figures depicting aspects of the present invention, in which:

FIG. **1** schematically shows a generic gas turbine engine to illustrate an example of a general environment in which the invention can be used;

FIG. **2** is a partially cutaway view of an airfoil in accordance with one possible embodiment of the present invention;

FIG. **3** is a cross-sectional view taken along line II—II FIG. **2**;

FIG. **4** is a view similar to FIG. **2**, showing an airfoil in accordance with another possible embodiment of the present invention;

FIG. **5** is a view similar to FIG. **2**, showing an airfoil in accordance with another possible embodiment of the present invention, and

FIG. **6** is a view similar to FIG. **2**, showing an airfoil in accordance with another possible embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates an example of a gas turbine engine **10** of a type preferably provided for use in subsonic flight, generally comprising in serial flow communication a fan **12** through which ambient air is propelled, a multistage compressor **14** for pressurizing the air, a combustor **16** in which the compressed air is mixed with fuel and ignited for generating an annular stream of hot combustion gases, and a turbine section **18** for extracting energy from the combustion gases. This figure illustrates an example of the environment in which the present invention can be used.

FIG. **2** shows a cross section of the rear portion of an airfoil **20** in accordance with one possible embodiment of the present invention. This airfoil **20** comprises one or more internal cooling passageways, which will be hereafter generally referred to as the passageway **22**. Air is supplied using one or more inlets **23** which generally communicate with openings (not shown) located under the airfoil **20**. Some of the cooling air usually exits the airfoil **20** from the passageway **22** through a network of small holes provided at various locations in the airfoil's sidewalls. Some of the cooling air is also sent towards the outlet located at the trailing edge **24** of the airfoil **20**.

Passageway **22** has at least three legs **22***a*, **22***b*, and **22***c*, respectively, which are divided by at least two perforated lands or crossovers **26** and **28**, respectively. Before cooling air passing through legs **22***a* and **22***b* may reach the leg **22***c* which communicates with the trailing edge **24**, the cooling air goes through at least one of preferably two crossovers **26**, **28** set across the airflow path. Crossover **28**, and preferably each of crossovers **26**, **28**, have a plurality of holes **30**, **32** respectively. As best shown in FIG. **3**, the crossovers **26**, **28** extend from a concave sidewall **34** to a convex sidewall **36** of the airfoil **20**. As also shown in the figures, lands **40** are preferably provided upstream of the trailing edge **24**, and are preferably aligned with the holes **32** in the crossover **28**.

The airfoil **20** also includes a plurality of elongated cooling fins **50** extending on the concave sidewall **34** between the crossover **28** and the trailing edge **24**. These fins **50** have a length greater than their width.

FIGS. **2** and **3** show that preferably, at least some of the fins **50**, more preferably all of them, are in aligned with and in registry with locations on the crossover **28** between the crossover holes **32**. The fins **50**, or at least some of the fins **50**, are preferably generally parallel to each other, and are straight and are generally aligned with the direction of the cooling air flow. Also, at least some of the fins **50** are preferably having their foremost end, with reference to the cooling air flow, in contact with the crossover **28**.

The fins **50** in FIGS. **2** and **3** extend to a location intermediate adjacent lands **40**, such that fins **50** and lands **40** interlace somewhat. FIG. **4** shows another alternative embodiment. In this embodiment, at least some of the fins **50** have a rearmost end positioned before the lands **40**.

FIG. **5** shows another alternate embodiment, in which at least some of the fins **50** have a rearmost end substantially aligned with a foremost end of at least some of the lands **40**. FIG. **6** shows another alternate embodiment, in which the fins have a foremost end spaced apart from the crossover.

As can be appreciated, the fins **50**, provided inside the concave sidewall **34** between the crossover **28** and the outlet at the trailing edge **24**, enhance the cooling of the airfoil **20** of a gas turbine engine **10**. Hence, the concave sidewall **34** remains relatively cooler without the need for increasing the amount of air.

Unlike the prior art, the present invention offers cooling advantages without significantly increasing the pressure drop in the cooling airflow path. Consequently, lower pressure bleed air is required to drive the cooling system, which is less thermodynamically "expensive" to the overall gas turbine efficiency.

The above description is meant to be exemplary only, and one skilled in the art will recognize that changes may be made to the embodiments described without department from the scope of the invention disclosed. For example, all fins are not necessarily parallel to each other, or linearly configured, although alignment with the flow direction is preferred. Holes in the crossovers need not necessarily be staggered. The fins can be used in conjunction with other features or devices to increase heat transfer inside an airfoil. The use of the fins is not limited to the turbine airfoils illustrated in the figures, and the invention may also be employed with turbine vanes, and compressor vane and blades as well. Still other modifications which fall within the scope of the present invention will be apparent to those skilled in the art, in light of a review of this disclosure, and such modifications are intended to fall within the appended claims.

What is claimed is:

1. An internally cooled airfoil for a gas turbine engine, the airfoil having at least one internal cooling passageway generally positioned between opposite concave and convex sidewalls, and a trailing edge outlet, the airfoil comprising:

a crossover located in the passageway and being adjacent to the trailing edge outlet, the crossover comprising a plurality of crossover holes; and

a plurality of elongated cooling fins provided inside the concave sidewall between the crossover and the trailing edge outlet, at least some of the fins being parallel to each other and generally parallel to the cooling air path.

2. The airfoil as defined in claim **1**, wherein at least some of the fins are in registry with locations on the crossover between crossover holes.

3. The airfoil as defined in claim **2**, wherein at least some of the fins are straight.

4. The airfoil as defined in claim **1**, wherein with reference to the cooling air path, at least some of the fins have a foremost end in contact with the crossover.

5. The airfoil as defined in claim **1**, wherein at least some of the fins have a foremost end spaced apart from the crossover.

6. The airfoil as defined in claim **1**, wherein spaced-apart lands are located between the crossover and the trailing edge outlet, at least some of the fins being out of alignment with the lands.

7. The airfoil as defined in claim **6**, wherein at least some of the fins have a rearmost end positioned before the lands.

8. The airfoil as defined in claim **6**, wherein at least some of the fins have a rearmost end substantially aligned with a foremost end of at least some of the lands.

9. The airfoil as defined in claim **6**, wherein at least some of the fins have a rearmost end located between at least some of the lands.

10. An airfoil for use in a gas turbine engine, the airfoil comprising a convex side, a concave side and a trailing edge at a rearmost portion of the airfoil, the airfoil having at least one internal cooling passageway, the airfoil comprising a plurality of internal cooling fins located inside the passageway and extending from the concave side upstream the trailing edge, at least some of the fins being parallel to each other and generally parallel to a cooling air path.

11. The airfoil as defined in claim **10**, wherein at least some of the fins are in registry with locations on the crossover between crossover holes.

12. The airfoil as defined in claim **11**, wherein at least some of the fins are straight.

13. The airfoil as defined in claim **10**, wherein with reference to a cooling air path, at least some of the fins have a foremost end in contact with a crossover.

14. The airfoil as defined in claim **10**, wherein spaced-apart lands are located between a crossover and the trailing edge, at least some of the fins being out of alignment with the lands.

15. The airfoil as defined in claim **14**, wherein at least some of the fins have a rearmost end positioned before the lands.

16. The airfoil as defined in claim **14**, wherein at least some of the fins have a rearmost end substantially aligned with a foremost end of at least some of the lands.

17. The airfoil as defined in claim **14**, wherein at least some of the fins have a rearmost end located between at least some of the lands.

18. A method of enhancing the cooling an airfoil of a gas turbine engine, the airfoil comprising at least one internal cooling passageway generally positioned between a concave sidewall and a convex sidewall, and a trailing edge outlet, the method comprising:

providing a crossover located in the passageway and adjacent to the trailing edge outlet, the crossover comprising a plurality of crossover holes;

providing a plurality of elongated cooling fins inside the concave sidewall between the crossover and the trailing edge outlet, at least some of the fins being substantially parallel to a cooling air path; and

circulating an airflow inside the passageway, the airflow running through the crossover holes and then over the fins before exiting at the trailing edge outlet.

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